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(71) Applicant: 000003551

Tokai Rika Denki Co., Ltd.

1, Noda, Toyota, Ouguchi-cho, Tanba-gun, Aichi-ken

(72) Inventor: Hitoshi Iwata

c/o Tokai Rika Denki Co., Ltd.

(74) Agent: Patent agent Hironobu Onda

(54) [Title] RAINDROP SENSOR AND RAINDROP-RESPONSIVE WINDSHIELD WIPER

(57) [Summary]

[Objective] To provide a raindrop-responsive windshield wiper that operates when a raindrop sensor detects the poor visibility of the windshield

[Solution] A raindrop sensor 13 of a raindrop-responsive windshield wiper 13 directly detects rain drops W adhered to a windshield 14 by acquiring an image of the windshield 14. The raindrop sensor 13 calculates a sum S of differences in brightness of all pixels G and issues the calculated sum S as a detection signal. A judging circuit 20, upon receiving the sum S, compares it with a threshold value S0. When the sum S reaches the threshold S0, it makes a judgment that the windshield 14 is causing poor visibility, and starts a windshield wiper motor 22 to operate a windshield wiper 15.

[Claims]

[Claim 1] Raindrop sensor comprising,

an image input means 16 that acquires an image of a specified region of an outside surface of a transparent member 14, and

a raindrop sensor equipped with an adhered amount detection means 17 that issues a detection signal (S) corresponding to an amount of adhered substance (W) adhered to said transparent member 14 based on brightness of each pixel (G) of the image received from said image input means 16.

[Claim 2] Raindrop sensor described in Claim 1, wherein said adhered amount detection means comprises,

an average brightness calculation means 17 that calculates average brightness of pixels (G) entered by said image input means 16,

a brightness difference calculation means 17 to calculate difference of brightness of each pixel (G) from the average brightness by said average brightness calculation means 17, and

a sum calculation means 17 that calculates a total of the differences in the brightness of each pixel (G) calculated by said brightness difference calculating means 17.

[Claim 3] Raindrop responsive windshield wiper that detects raindrops (W) adhered to a windshield 14 and wipes the raindrops off in a manner corresponding to the amount of raindrops by operating a windshield wiper 15, more specifically, a raindrop responsive windshield wiper comprising,

a raindrop sensor described in Claim 1 or 2 that detects raindrops (W) adhered to a specified region of the windshield 14 and issues a detection signal (S) that corresponds to the amount of said raindrops,

a judging means 20 that makes a judgment on whether visibility through said windshield 14 is poor or not based on the amount of raindrops detected by said raindrop sensor 13, and

a windshield wiper driving means 21-22 that drives said windshield wiper 15 based on the judgment made by said judging means.

[Claim 4] Raindrop-responsive windshield wiper described in Claim 3, wherein said judging means 20 compares the detection signal (S) that corresponds to the amount of raindrops detected by said raindrop sensor 13 with a predetermined threshold value (S0) and makes a judgment whether visibility through said windshield 14 is poor or not based on the result of said comparison.

[Claim 5] Raindrop-responsive windshield wiper described in Claim 3 or 4, wherein said raindrop sensor 13 is provided on an inner mirror 12 of an automobile 11 and detects raindrops W adhered to a wiping range of the windshield wiper 15.

[Detailed explanation of the invention]

[0001]

[Technological field of the invention] The invention relates to the raindrop sensor and the raindrop-responsive windshield wiper, more specifically, the raindrop sensor that detects the raindrops adhered to the windshield, and the raindrop-responsive wiper that wipes said raindrops.

[0002]

[Prior art] The driver of an automobile has to operate the wiper switch appropriately when it rains depending on the driving condition and the amount of raindrops that adhere to the windshield. Therefore, some automobiles are equipped with raindrop-responsive windshield wipers that operate automatically when it rains and wipe out the raindrops adhered to the windshield. The raindrop-responsive windshield wiper detects the rainfall by means of the raindrop sensor and automatically changes the operating cycle of the windshield wiper according

to the detected rainfall, thus alleviating the driver's trouble of switching the wiper speeds and cycles.

[0003] The raindrop sensor can be a capacity sensor, vibration sensor, light reflection sensor, etc. The capacity sensor and the vibration sensor detect the amount of raindrops that fall on a certain area where the sensor is installed, and issues a detection signal relative to the amount of raindrops. The light reflection sensor detects the amount of light of the reflection caused by the light entering the windshield and being reflected off the raindrops adhered to the windshield, and issues a detection signal relative to the amount of light.

[0004]

[Problems to be solved by the invention] The problem of the capacity sensor and the vibration sensor is that they do not detect the actual condition of the raindrops adhered to the windshield, but rather they indirectly detect the condition of raindrops adhered to the entire windshield based on the detection of the raindrops fell on the sensors. Although the light reflection sensor detects the condition of the raindrop adherence to the actual windshield, the problem is that its detection range is narrow and it detects only the raindrops accidentally fallen on the spot of the windshield where it is lighted, so that the result can be different from the actual raindrop adherence condition of the entire windshield.

[0005] The present invention intends to solve the above problems and provide a raindrop sensor that detects the poor visibility through the windshield as well as to provide a raindrop-responsive windshield wiper using such a raindrop sensor.

[0006]

[Means of solving the problems] The invention described in Claim 1 is about a raindrop sensor comprising, an image input means that acquires an image of a specified region of an outside surface of a transparent member, and a raindrop sensor equipped with an adhered amount detection means that issues a detection signal corresponding to an amount of adhered substance adhered to said transparent member based on brightness of each pixel of the image received from said image input means.

[0007] The invention described in Claim 2 is about a raindrop sensor described in Claim 1, wherein said adhered amount detection means comprises, an average brightness calculation means that calculates average brightness of pixels entered by said image input means, a

brightness difference calculating means to calculate difference of brightness of each pixel from the average brightness by said average brightness calculation means, and a sum calculation means that calculates a total of the differences in the brightness of each pixel calculated by said brightness difference calculating means.

[0008] The invention described in Claim 3 is about a raindrop responsive windshield wiper that detects raindrops adhered to a windshield that wipes the raindrops off by driving a windshield wiper in a manner corresponding to the amount of raindrops, more specifically, a raindrop responsive windshield wiper comprising, a raindrop sensor described in Claim 1 or 2 that detects raindrops adhered to a specified region of the windshield and issues a detection signal that corresponds to the amount of said raindrops, a judging means that makes a judgment on whether visibility through said windshield is poor or not based on the amount of raindrops detected by said raindrop sensor, and a windshield wiper driving means that drives said windshield wiper based on the judgment made by said judging means.

[0009] The invention described in Claim 4 is about a raindrop-responsive windshield wiper described in Claim 3, wherein said judging means compares the detection signal with a predetermined threshold value and makes a judgment whether visibility through said windshield is poor or not based on the result of said comparison.

[0010] The invention described in Claim 5 is about a raindrop-responsive windshield wiper described in Claim 3 or 4, wherein said raindrop sensor is provided on an inner mirror of an automobile and detects raindrops adhered to a wiping range of the windshield wiper.

[0011] Consequently, according to the invention of Claim 1, the image input means captures the image of a specified area of the transparent member and issues a detection signal corresponding to the amount of substance adhered to the transparent member detected by the adherence amount detection means based on the brightness of each pixel of the image.

[0012] According to the invention of Claim 2, the adherence detection means consists of the average brightness calculation means, the brightness difference calculation means, and the sum calculation means. The average brightness calculation means calculates the average brightness of pixels of the image entered by the image input means. The brightness difference calculation means calculates the difference between the average brightness calculated by the average brightness calculation means and the brightness of each pixel. The sum calculation means

calculates the sum of the difference of the brightness of each pixel calculated by the brightness difference calculation means and the sum is issued as the detected signal corresponding to the amount of the adhered substance.

[0013] According to the invention described in Claim 3, the raindrop sensor detects the raindrops fallen on the specified region of the windshield, and issues the detection signal corresponding to the amount of raindrops. A judgment is made whether the visibility through the windshield is poor not based on the detected signal, and the windshield wiper is driven to wipe off the raindrops fallen on the windshield based on said judgment.

[0014] According to the invention described in Claim 4, the detection signal received from the raindrop sensor is compared with a predetermined threshold value, and whether the visibility through the windshield is poor or not is determined based on said comparison result.

[0015] According to the invention described in Claim 5, the raindrop sensor is installed on the inner mirror of the automobile to detect he raindrops adhered to the wiping area of the windshield wiper.

[0016]

[Embodiment of the invention] An embodiment of the present invention will be explained referring to Fig. 1 through Fig. 4. As shown in Fig. 1, an inner mirror 12 of an automobile 11 is equipped with a raindrop sensor 13, which functions as the image input means. The raindrop sensor 13 is used to detect the adhered substance such as raindrops adhered to a windshield 14 so that the adhered substance can be wiped off by operating a windshield wiper 15. The raindrop sensor 13 captures the image of the predetermined region of the windshield 14. The raindrop sensor 13 then detects the raindrops as the substance adhered on the windshield 14 based on the input image and issues a detection signal corresponding the amount of raindrops.

[0017] As shown in Fig. 3, the raindrop sensor 13 comprises a CCD camera 16 and a pixel brightness calculation circuit 17. As shown in Fig. 2, the CCD camera 16 is equipped with a lens 18 and a CCD 19. The lens 18 has a shallow focus depth (e.g., 1 meter). As a result, the image of the outer proximity of the windshield 14, more specifically the image of the raindrops W adhered to the windshield 14 is formed on the CCD 19. On the other hand, the sights around the automobile 11 are not formed on the CCD 19, so that the amount of light entering the CCD 19 is about constant.

[0018] The CCD 19 is typically a monochromatic two dimensional CCD with 100 x 100 = 10,000 pixels. The CCD 19 receives the image of the predetermined region (e.g., 50 mm x 50 mm) of the windshield 14 by means of the lens 18. The size of this region is set up sufficiently larger than the size of the raindrop sensor of the prior art. Also, the region is set up within the area of the windshield 14 wiped by the wiper 15. The CCD 19 issues the signal (brightness) of each pixel entered to the pixel brightness calculation circuit 17.

[0019] The pixel brightness calculation circuit 17 calculates the average X of the brightness of the pixels entered from the CCD camera 16 and the sum S of the differences between the brightness of each pixel and the average X. The pixel brightness calculation circuit 17 issues the calculated sum S as the detection signal to a decision circuit 20.

[0020] Fig. 4 (a) shows the pixels G of the image of the windshield 14 when there are not raindrops W and Fig. 4 (b) shows the pixels G of the image of the windshield 14 when raindrops W are adhered thereto. Fig. 4 (a) and Fig. 4 (b) both show only 5 x 5 =25 pixels G.

[0021] When there are no raindrops W adhered to the windshield 14 as shown in Fig. 4 (a), the sights of the things away from the windshield 14 will not be formed on the CCD 19 because the focus depth of the lens 18 is shallow, making the entire region on the same brightness level. At this time, the average brightness X of the pixels G coincides with the brightness of each pixel G, so that the sum S of the differences between the average X and the brightness of each pixel G becomes zero (S=0).

[0022] When raindrops W, etc. adhere to the windshield 14, images are formed locally on pixel G due to the adhered substances as shown in Fig. 4 (b). This causes differences between the brightness of the pixels G where the raindrops W are adhered and the pixels G where no raindrops W are adhered to. At this time, the pixel brightness calculation circuit 17 first determines the average X of the brightness of the pixels G. Next, the pixel brightness calculation circuit 17 determines the difference between the average X and the brightness of each pixel G and the sum S of the differences in the brightness the pixels G. The sum S is the variation of the brightness of each pixel G, so that the larger the quantity of the raindrops W adhered to the windshield 14, the larger the sum S.

[0023] In other words, the calculated sum S corresponds to the quantity of the raindrops adhered to the windshield 14. The larger the sum S, the less uniform the brightness of the pixels

G of the image of the windshield 14. In other words, the driver has difficulty in seeing forward because of a large amount of raindrops W adhered to the windshield 14.

[0024] Therefore, the raindrop sensor 13 captures the image of the windshield 14 and directly detects the raindrops W adhered to the windshield 14 and calculates the sum S of the differences in the brightness of each pixel G corresponding to the amount of raindrops W detected. The raindrop sensor 13 then issues the sum S as the detection signal. The region that is covered by the raindrop sensor 13 is sufficiently larger than the region covered by the raindrop sensors of the prior art, the condition of the raindrops W is close to the raindrop adherence condition over the entire windshield 14.

[0025] Moreover, the average X of the brightness of the pixels G is calculated so that the result is less susceptible to the change of the light on the outside. For example, during the daytime and in the area where there are lots of lighting such as street lights, the brightness of the images entering the pixels G are brighter, while they are darker otherwise. Therefore, the change of the brightness of the pixels G due to the existence or lack of raindrops W is smaller than the change of brightness between daytime and night, and is more difficult to be detected. Therefore, the average X of the brightness of the pixels G is calculated first, and then the difference between the average X and the brightness of each pixel G is calculated, so that the change of the brightness of the entire windshield 14 can be cancelled out to make the change of the brightness due to raindrops W easily detected.

[0026] The decision circuit 20 receives the sum S as the detection signal output from the pixel brightness calculation 17. The decision circuit 20 receives an input of a predetermined threshold value S0. The judgement circuit 20 compares the sum S and the threshold value S0 and makes a judgement whether the visibility through the windshield 14 is poor or not.

[0027] The threshold value S0 is determined in advance by experiments as the value where the driver decides that it is difficult to see through the windshield 14 due to adhered substance such as raindrops W adhered to the windshield 14 so that the windshield wiper 15 needs to be operated. Therefore, if the sum S is smaller than the threshold value S0, the driver can see forward and if the sum S is larger than the threshold value S0, the driver has difficulty seeing forward. If the windshield wiper 15 is operated to wipe off the raindrops W adhered to the windshield 14 when the sum S reaches the threshold S0, the driver can have a better view.

[0028] In other words, the decision circuit 20 decides that the visibility through the windshield 14 is good if the sum S received as an input is smaller than the threshold value S0, and if the sum S is larger than the threshold value S0, it decides that the visibility through the windshicld 14 is poor. The sum S becomes larger when there is a larger amount of raindrops W adhered to the windshield 14, and becomes smaller when there is a smaller amount of raindrops W. Therefore, the decision circuit 20 compared the sum S and the threshold value S0 in order to compare the amount of raindrops adhered tot he windshield 14 and the predetermined amount, thus to make a judgment whether the current amount of raindrops W is large or small. The decision circuit 20 issues the signal to the drive circuit 21 depending on the judgment result.

[0029] The drive circuit 21 is connected to the wiper motor 22 that drives the windshield wiper 15. The drive circuit 21 is connected to a manual switch 23 and an auto switch 24. The manual switch 23 is a common wiper control switch, which performs intermittent operations of predetermined timing, low speed operations, and high speed operations when it is turned on, although only one circuit is shown. When the manual switch 23 is turned on, the drive circuit 21 controls the drive of the wiper motor 22 to operate the windshield wiper 15 to wipe the windshield 14.

[0030] The auto switch 24 is built into the aforementioned wiper control switch. When the auto switch 24 is turned on, the drive circuit 21 controls the wiper motor 22 based on the input signal received from the decision circuit 20 to operate the wiper 15 and wipe the windshield 14. The signal which enters the drive circuit 21 from the decision circuit 20 corresponds to the poor visibility through the windshield 14, i.e., the amount of the raindrops W adhered to the wind shield. Therefore, when the visibility through the windshield 14 becomes poor, the drive circuit 21 drives the wiper motor 22 to operate the windshield wiper 15 thus to wipe the front window 14 to make the front window 14 easier to see through.

[0031] The raindrop-responsive wiper consists of said raindrop sensor 13, decision circuit 20, drive circuit 21, wiper motor 22, and wiper 15, and wipes substances such as raindrops W adhered to the windshield 14.

[0032] The sum S calculated by the pixel-brightness-calculation circuit 17 varies with the amount of raindrops W adhered to the windshield 14. Therefore, the sum S reaches the threshold S0 quicker when the rainfall is larger than when the rainfall is smaller. Therefore, the

windshield wiper 15 operates intermittently with a shorter interval when the rainfall is larger, to wipe off the raindrops adhered to the windshield 14. When the raindrops are wiped off, the difference of brightness of each pixel G raindrop detected by sensor 13 disappears, thus making the sum S = 0 to reset it again.

[0033] As we mentioned above, the embodiment of the present invention provides the following benefits:

(1) Raindrop sensor 13 captures the image of the windshield 14 and directly detects the raindrops W adhered to the windshield 14. The raindrop sensor 13 calculates the sum S of the differences in the brightness of each pixel G, which corresponds to the amount of raindrops W detected, and issues the calculated sum S as the detection signal. By doing so, it can detect the raindrops W actually fallen on the windshield 14, and detect the visibility (or lack of it) based on the amount of raindrops.

[0034] (2) The raindrop-responsive windshield wiper is designed in such a way that the windshield wiper15 is operated when the sum S of the differences in the brightness of each pixel G, which is caused by the raindrops W adhered to the windshield 14 and detected by the raindrop sensor 13, reaches the threshold value S0. As a result, it is possible to operate the windshield wiper 15 with a shorter interval when the rainfall is larger than when the rainfall is smaller, in other words, it is possible to drive the windshield wiper 15 in response to the amount of raindrops. This eliminates the cumbersome switching between different operating modes of the windshield wiper 15, and allows the driver to drive in a more comfortable manner.

[0035] The invention can be changed as follows and still accomplish the same operations and effects.

(1) Although the raindrop sensor 13 is built into the inner mirror 12 in the above-mentioned embodiment to detect the raindrops adhered to the windshield 14, the location of the raindrop sensor 13 can be altered appropriately. The raindrop sensor 13 can be located anywhere as long as it can detect am area inside the wiping range of the windshield wiper 15; for example, it can be built into the instrument panel 31 as shown in Fig. 5.

[0036] (2) Although the windshield wiper 15 is arranged in the above-mentioned embodiment to operate to wipe raindrops W when the sum S of the detected amount of raindrops reaches the threshold value S0 by controlling the wiper motor 22, it can be arranged in such a way that the

interval of intermittent operation of the wiper motor 22 is changed according to the amount of raindrops detected.

[0037] (3) Although the raindrop-sensitive windshield wiper 15 is arranged in the above-mentioned embodiment in such a way that the windshield wiper 15 is operated intermittently in accordance with the amount of raindrops W adhered to the windshield 14, the raindrop-sensitive windshield wiper can be arranged instead to operate the rear window wiper intermittently.

[0038] (4) Although a CCD 19 is used in the above-mentioned embodiment as the image input means, phototransistor array, photodiode array, etc., can be used instead.

(5) In the above-mentioned embodiment, the number of pixels of the CCD19 can be arbitrarily changed. Also, the size of the detected region can be changed appropriately.

[0039] The followings are the technological ideas of the invention that can be observed from each embodiment style in addition to the items claimed:

(a) The adhered substance detection device of Claim 1 or 2 wherein said adhered substances are raindrops W. With this constitution, the amount of raindrops that adhered within the specified region of the transparent body can be easily detected.

[0040] (b) Raindrop-responsive windshield wiper of Claim 3 or 4 wherein said raindrop sensor 13 is provided in the instrument panel 31 of the vehicle 11 to detect the raindrops W adhered within the wiping range of the wiper 15. Such a constitution enables us to detect raindrops W adhered within the wiping range of the wiper 15 easily.

[0041]

[Effects of the invention] The invention, as described above in details, provides a raindrop sensor that enables us to detect poor visibility through the windshield. If can also provide a raindrop-sensitive windshield wiper.

[Brief explanation of the drawings]

[Fig. 1] Outline side view of an automobile equipped with a raindrop sensor of one embodiment of the invention.

[Fig. 2] Outline of the CCD camera

[Fig. 3] Electrical block diagram of the raindrop-sensitive windshield wiper

[Fig. 4] (a) is an outline showing the captured pixels. (b) is an outline showing the pixels with the input of adhered raindrops.

[Fig. 5] Outline side view showing other types of embodiments.

[Keys]

| | |
|---|---|
| 11 | automobile |
| 12 | inner mirror |
| 13 | raindrop sensor |
| 14 | windshield as a transparent member |
| 15 | windshield wiper |
| 16 | CCD camera as an image input means |
| 17 | pixel brightness calculation circuit, as an adherence amount detection means, an average brightness calculation means, a brightness difference calculation means, and a sum calculation means |
| 18 | decision circuit as a judgment means |
| 19 | drive circuit as a wiper drive means |
| 20 | wiper motor as a wiper drive means |
| S | sum as a detection signal |
| S0 | threshold value |
| G | pixel |
| W | raindrops as adhered substances |